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WHITE SPRUCE CONE AND SEED PRODUCTION IN INTERIOR ALASKA, 1957-68

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ABSTRACT

Estimates of seedfall per acre, seed dispersal over time, cone production by individual trees, number of seeds per cone and per tree, and cone crop rating are reported from white spruce stands in interior Alaska for the period 1957-68. These observations indicate that very good seed years may be separated by at least 10 to 12 years although, during this interval, individual stands may produce from one to several fair or good cone crops.

During the period 1957-68, investigators have studied various aspects of white spruce cone and seed production in interior Alaska. Their findings are scattered in journals, office reports, research papers, annual reports, and unpublished master's theses and are not readily available. We have summarized this knowledge, used data from our own studies, and made general conclusions about white spruce seed production, an extremely important factor in both natural and artificial regeneration of white spruce.

[1/] We would like to acknowledge the work done by Drs. Robert Funsch and Robert A. Gregory in their investigations of seed production in Alaska from 1957 to 1962 and the field and laboratory assistance of Mrs. Joan Foote.

CONE CROP RATINGS

Cone crop estimates for varying numbers of stands have been made annually from 1957-68 (except in 1963). Werner's (1964) data for the period 1958-61 are the most complete and are an average value for a number of stands in interior Alaska along the Nenana and Alaska Highways (fig. 1). The data for the remaining years are for individual stands in the vicinity of Fairbanks, Alaska (1964-65 data from Smith[2/]).

The cone crop rating system of 1 to 10, used by investigators in Alaska, admittedly is subjective and distinguishing between two adjacent ratings on the scale is often difficult. However, we feel that it does provide a reliable basis for comparing the relative cone production between stands and between individual years.

Cone Crop Rating System

Class	Rating
Very poor	1. No cones on any trees
	2. Few cones on occasional trees
Poor	3. Few cones on 25 percent of trees
	4. Few cones on 25 percent of trees--many cones on occasional trees
Fair	5. Few cones on 75 percent of trees
	6. Few cones on 75 percent of trees--many cones on some trees
Good	7. Some cones on all trees
	8. Many cones on some trees--some cones on all trees
Very good	9. Many cones on 75 percent of trees--some cones on all trees.
	10. Many cones on all trees

[2/] M. C. Smith. Red squirrel *(Tamiasciurus hudsonicus)* ecology during spruce cone failure in Alaska. 1967. (Unpublished master's thesis on file at Univ. Alaska, College.)

From the tabulation shown below, we can make the following observations. The 1958 crop was generally good to very good throughout the interior. Based on these data, the next best crop may have occurred in 1968; however, in 1966 and 1967 good crops were observed in individual stands. Cone crops for the years 1959-65 generally were poor to fair.

Year	Cone crop rating	Study area
1957	5	Bonanza Creek-2
1958	9	Fairbanks vicinity
	9	Bonanza Creek-2
	8-9	Tanana Valley (Fairbanks to George Lake)
	8	Gerstle River
	8	Steese Highway (Central to Circle)
1959	4	Fairbanks vicinity
	4	Bonanza Creek-2
1960	3	Fairbanks vicinity
1961	3	Fairbanks vicinity
1962	4	Bonanza Creek-2
1963	--	--
1964	2	Bonanza Creek-1
1965	1	Bonanza Creek-1
1966	3-4	Fairbanks vicinity
1967	4-5	Bonanza Creek-1
	7	Bonanza Creek-2
	7	Chena River-1
	8	Chena River-2
1968	7	Bonanza Creek-1
	7	Bonanza Creek-2
	7	T-field
	7	Gerstle River

However, even during poor to fair years, it is possible to locate stands or individual trees which produce better than average cone crops. Table 1 indicates the variation which existed for the average values reported by Werner (1964) for the years 1959-61.

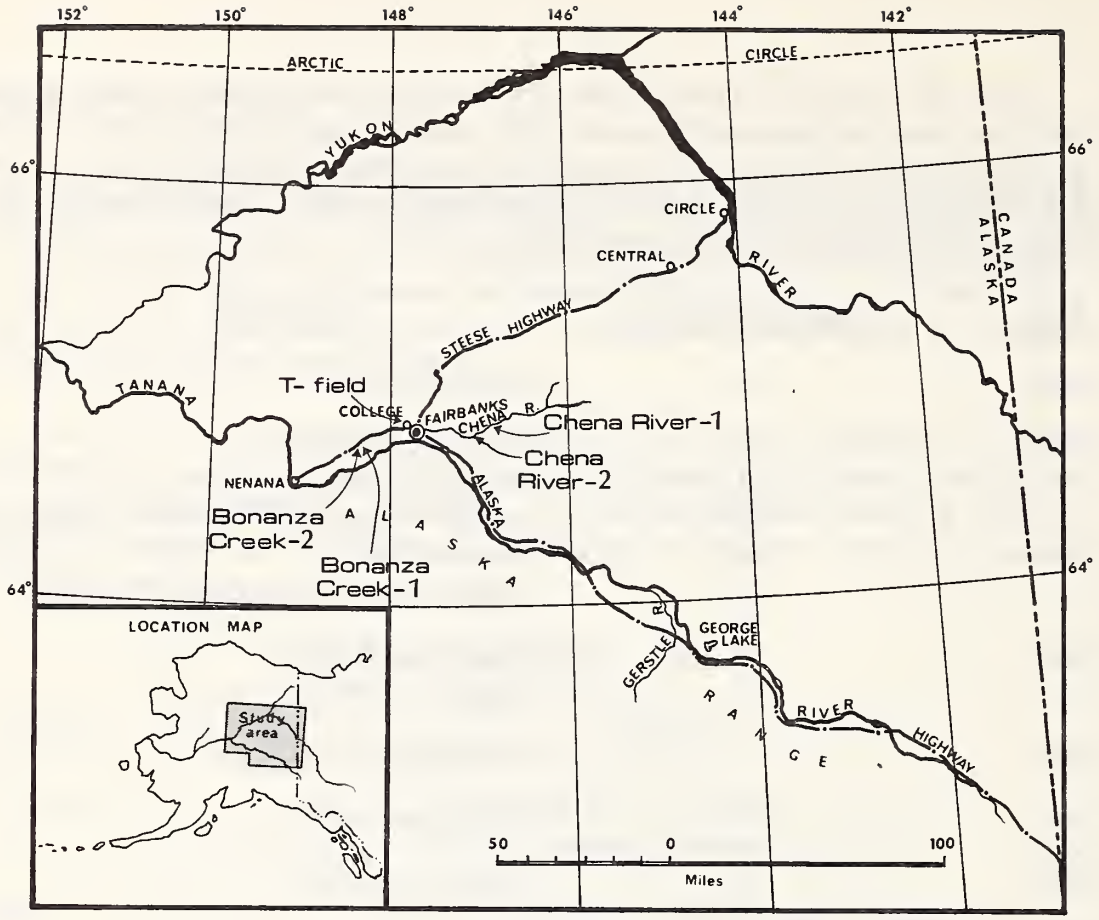

Figure 1.--*Location of study areas in interior Alaska, 1957-68.*

Table 1.--*Number of stands*[1/] *in each cone crop class along the Nenana and Alaska Highways, 1959-61*

Year and location	Cone crop ratings									
	1	2	3	4	5	6	7	8	9	10
1959:										
Nenana Highway	8	8	6							
Alaska Highway			3	10		7				
1960:										
Nenana Highway			3	2	3	5	1			
Alaska Highway	8	7	8	8	4	5				
1961:										
Nenana Highway		1	2	5	6	5				
Alaska Highway	1	13	4	8	5	3				

[1/] Stands in which ratings were made generally described as well to moderately well stocked and mixed in composition (e.g., white spruce-black spruce and white spruce-hardwood).

Table 2.--*Cone production of selected white spruce during 1967 and 1968*

Year and area	Tree number									
	1	2	3	4	5	6	7	8	9	10
	Number of cones									
1967:[1/]										
Bonanza Creek-1	8	40	15	50	90	75	130	15	90	20
Bonanza Creek-2	250	75	50	40	140	80	30	80	130	120
1968:[2/]										
Chena River-1	587	289	879	390	619	1,010	1,234	2,251		
Bonanza Creek-2	1,977	1,873								

[1/] Cone counts made of dominant trees from the ground with binoculars.

[2/] Cone counts are actual counts of cones picked from felled trees; these trees were dominants and selected because they had large quantities of cones.

CONE PRODUCTION BY INDIVIDUAL TREES

In 1967, 10 dominant white spruces in Bonanza Creek-1 produced an average of 53 cones per tree during a fair year (rating 4); at Bonanza Creek-2, 10 dominants produced an average of 77 cones per tree during a good year (rating 7). These counts were made with binoculars. During the fall of 1968, trees which appeared to have produced more cones than their immediate neighbors were felled and all the cones were collected and counted. Two such trees at Bonanza Creek-2 produced an average of 1,925 cones per tree, and eight trees near the Chena River-1 plot, an average of 907 (table 2).

QUANTITY AND QUALITY OF SEED IN CONES

Although annual variation in the average number of seeds and percent of sound seed per cone (table 3) exists, the best cone and seed year on record (1958, rating 8-9) appears to have produced the highest average number of seeds (83) and the highest sound seed percentage (74). Other years produced an average of 31 seeds per cone with about 37 percent sound (1959, rating 4); 12 seeds per cone, 53 percent sound (1960, rating 3); and 65 seeds per cone, 38 percent sound (1961, rating 3) (Werner 1964 and Northern Forest Experiment Station 1960-61). In 1968, cones of individual trees (table 3, trees 3 and 8) in the Chena River-1 area produced seed with about the quantity and quality of that produced in 1958, but the average for all trees (52 seeds per cone, 64 percent sound) was below the 1958 average.

Tables 2 and 3, considered together, provide an estimate of the quantity of seed produced in 1968 by trees in the vicinity of the Chena River-1 and Bonanza Creek-2 stands:

Area	Total seeds per tree	Sound seeds per tree
Chena River-1	54,490	34,873
Bonanza Creek-2	63,666	38,776

SEEDFALL IN UNDISTURBED WHITE SPRUCE STANDS

The seedfall data for Bonanza Creek-2 (table 4) seems to indicate that a direct relationship may exist between cone crop rating and both total seedfall and the quantity of sound seed per acre. However, this relationship is confounded by such factors as disease *(Chrysomyxa pirolata)* (Zasada and Gregory 1969), frost,[3] insects (Werner 1964), and the red squirrel *(Tamiasciurus hudsonicus)* (Brink,[4] Smith,[5] Streubel,[6] Brink and Dean 1966). Werner's data showed that, in years with similar cone crop ratings (rating 3-4 in 1959, 1960, 1961), insect damage to seed may vary significantly: 1959--11.5 sound seeds per cone; 1960--6.5 sound seeds; and 1961--24.7 sound seeds (table 3). This would result in similar variation in the quality of seedfall. During 1967, Streubel estimated that squirrels harvested between 59 and 88 percent of the cone crop on plots with active middens and between 4 and 21 percent on plots without active midden areas. This would greatly reduce the "effective" cone crop and the quantity of seed dispersed.

Dispersal of the annual seed crop usually begins during mid- to late-August. Although seed continues to fall during the next year, the majority of the seed is dispersed over a relatively short period of time (2-3 months). For example, it appears that the first dispersal of any of the 1968 seed crop occurred between August 13 and 20 in three of four study stands. The greatest quantity of seed fell during the first 7 to 10 days of September; and 79 to 87 percent of the seedfall for the 4½-month observation period (August 6 to mid-December) occurred during September and October (fig. 2 and table 5).

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[3] J. C. Zasada, in preparation.

[4] C. H. Brink. Spruce seed as a food of the squirrels *(Tamiasciurus hudsonicus)* and *Glaucomys sabrinus* in interior Alaska. 1964. (Unpublished master's thesis on file at Univ. Alaska, College.)

[5] See footnote 2, p. 2.

[6] D. P. Streubel. Food storing and related behavior of red squirrels *(Tamiasciurus hudsonicus)* in interior Alaska. 1968. (Unpublished master's thesis on file at Univ. Alaska, College.)

Table 3.--*White spruce seed and seed quality based on extraction of seed collected from individual cones*

Year and tree number	Average number seeds per cone[1/2/]	Sound seed per cone	Percent sound seed[3/]
1958	83.3(11-146)	62.1	74.1(0-100)
1959	30.7(0-116)	11.5	37.4(0-86)
1960	12.2(0-66)	6.5	53.3(0-100)
1961	64.6(15-135)	24.7	38.2(0-82)
1962:			
Nenana Highway-1	43.1	24.1	55.9
Nenana Highway-2	61.8	14.6	23.6
Nenana Highway-3	80.2	23.1	28.8
$\bar{X}$	61.7	20.6	36.1
1968, Chena River-1:			
Tree 1	34.3	25.7	74.9
2	41.6	34.1	82.0
3	80.3	51.3	63.9
4	32.3	14.5	44.9
5	46.6	20.5	44.0
6	48.3	25.1	52.0
7	51.5	22.1	42.9
8	79.7	61.3	76.9
Random collection (from felled trees)	52.9	25.9	49.0
$\bar{X}$	51.9	31.2	63.6
1968, Bonanza Creek-2:			
Tree 1	41.1	27.1	65.9
2	24.6	12.8	52.0
Random collection (from crowns of six trees)	41.0	25.8	62.9
$\bar{X}$	35.6	21.9	60.3

1/ Values in parentheses denote range.

2/ 1968 data are based on seed extracted from a random sample of 10 cones from each tree except where stated.

3/ 1968 data on percent sound seed are based on cutting test of 200 seeds for each tree.

CONCLUSIONS

Although these data are limited, they do provide some useful information concerning cone and seed production in white spruce stands of interior Alaska. Using this information, we can make several general statements.

The between-stand variation in cone and seed production for any given year in an area the size of interior Alaska or even a drainage, such as that of the Yukon or Tanana Rivers, can be significant. Therefore, conclusions concerning the cone and seed crop in such areas based on observations from only one or two stands may be misleading. Similarly, an average value for any cone and seed production parameters for stands or even trees within a stand, although useful, may be of limited value for a particular stand or tree. This variation (both between stands and between trees) seems to be consistent with that reported for white spruce in other parts of its range[7] and for Norway spruce in Finland (Sarvas 1968) and Sweden (Andersson 1965), but not with Waldron's[8] cone crop data for white spruce in Saskatchewan and Manitoba.

The interval between very good cone and seed years may be closer to the 12-13 years reported by Sarvas (1957) for Norway spruce in Finland than the 6-7 years in the Prince George Forest District of British Columbia,[8] or the 3-4 years in the Duck Mountain and Porcupine Forest Reserves in Manitoba (Rowe 1955). However, the Alaska data seem to indicate that between the generally very good cone and seed years individual stands will produce from one to several fair or good cone crops.

Assuming that mortality of enlarging conelets is negligible, cone counts made prior to the harvest of cones by red squirrels (i.e., before August 1) provide the best estimate for determining periodicity of cone and seed crops. Seed trap studies, although they may directly relate to cone crop, provide an estimate of the seed reaching the ground and potentially available for natural regeneration but are probably not as reliable for determining the actual periodicity of cone and seed crops as July cone counts.

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[7] John Revel, British Columbia Forest Service, Red Rock Nursery, Prince George, B. C., personal correspondence.

[8] R. M. Waldron. Annual cone crops of white spruce in Saskatchewan and Manitoba 1923-1964. Can. Dep. Forest., Forest Res. Br., Progr. Rep., Proj. MS-158, 34 pp. 1965.

Table 4.--*Seedfall*[1/] *in undisturbed white spruce stands*

Year and place	Cone crop rating	Seed	Sound seed	Sound seed[2/]
		- - *Thousands per acre* - -		*Percent*
1957:				
Bonanza Creek-2	5	138	86	62
1958:				
Bonanza Creek-2	9	16,512	10,733	65
1959:				
Bonanza Creek-2	4	123	27	22
1968:				
Bonanza Creek-2	7	334	136	41
Bonanza Creek-1	7	227	85	37
Chena River-1	7	214	55	26
T-field	7	396	157	40

[1/] Estimate obtained from seed collected in 1/4-milacre-square seed traps.

[2/] Determined from cutting tests of all seed collected in seed traps.

Table 5.--*Total seedfall dispersed during monthly intervals for the period August to mid-December*

Interval	Bonanza Creek-1		Bonanza Creek-2		Chena River-1		T-field	
	Total seedfall	Filled seed	Total seedfall	Filled seed	Total seedfall	Filled seed	Total seedfall	Filled seed
	- - - - - - - - - - - - - - - - - *Percent* - - - - - - - - - - - - - - - - -							
Aug. 6-Aug. 27	7.2	7.8	10.5	6.3	10.7	3.0	9.0	7.3
Aug. 27-Sept. 27	57.7	65.8	62.2	74.2	59.3	64.4	71.4	77.6
Sept. 27-Oct. 25	21.1	18.9	18.8	16.9	19.3	22.2	[1/]15.8	12.7
Oct. 25-Dec. 16	14.0	7.5	8.5	2.6	10.7	10.4	[2/]3.8	2.4

[1/] Sept. 27-Nov. 4.
[2/] Nov. 5-Dec. 16.

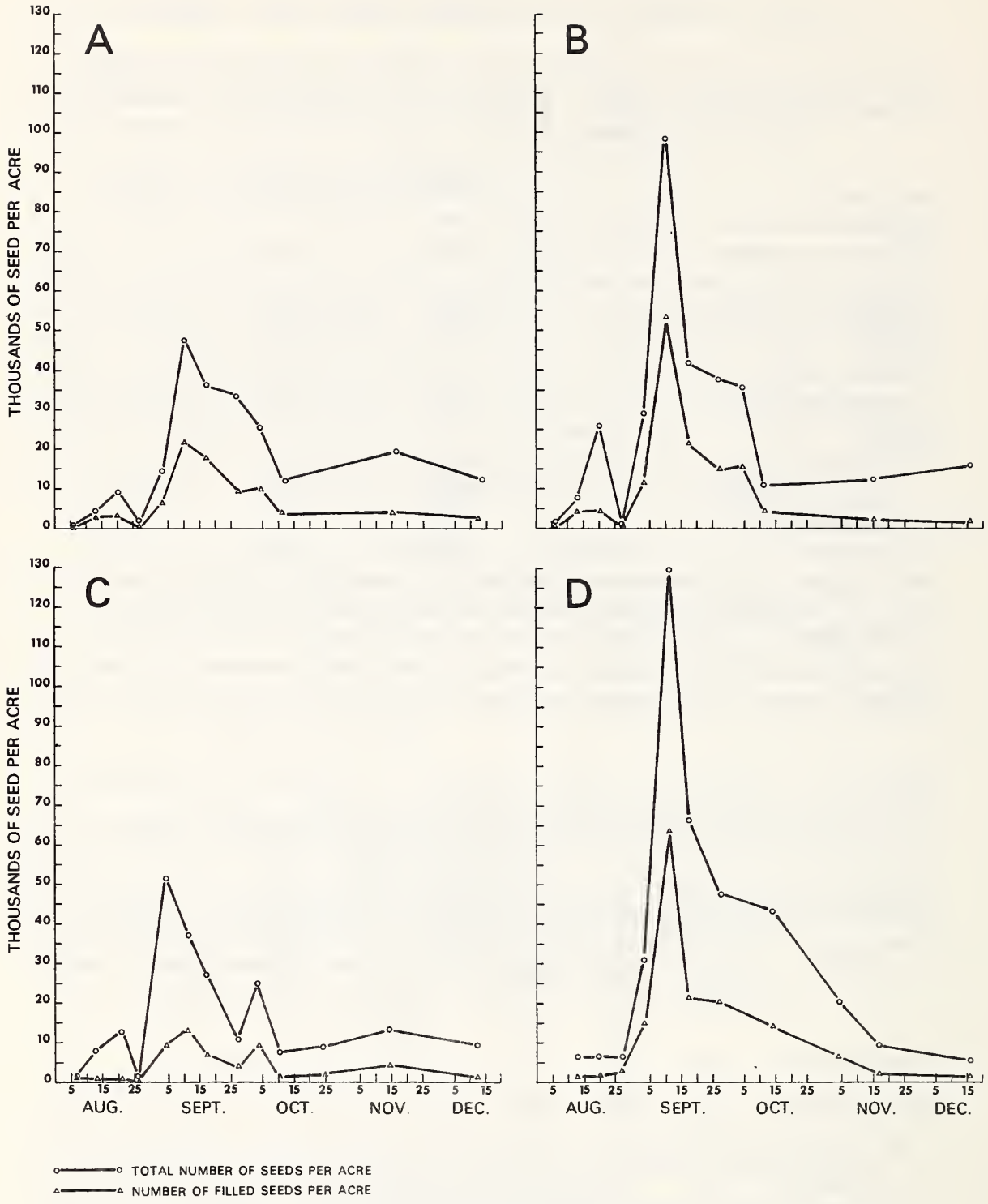

Figure 2.--*1968 seedfall for the period August to mid-December. A. Bonanza Creek-1; B. Bonanza Creek-2; C. Chena River-1; D. T-field. (Seed collected at about weekly intervals from August 6 to mid-October and once in November and December. Collections at the T-field plot were slightly different.)*

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